A1 concl.

edge of sample 110 is in field of view 130. Position 112 is offset to the right from the central position of sample 110 by the radius r of sample 110. A position 116 for viewing the right edge of sample 110 is offset a distance r to the left along the X axis from the central position. Accordingly, the X,Y stage must have a travel distance of 2r along the X axis for edge-to-edge inspection of sample 110. Similarly, the X,Y stage must have a travel distance of 2r along the Y axis between positions 114 and 118, and a minimum area 120 required for an X,Y stage capable of positioning sample 110 for edge-to-edge viewing is about $16*r^2$.

Please replace the paragraph starting on page 2, line 11 with the following replacement paragraph.

A2

Many applications require the sample to be accurately positioned and oriented or at least require accurate information regarding the position and orientation of the sample relative to the X,Y stage. This requirement is common in automated semiconductor manufacturing where the samples are generally round semiconductor wafers. A wafer's position can be accurately determined by rotating the wafer about a rotation axis and monitoring the variation in the perimeter location of the wafer as a function of the rotation. An analysis of the measured perimeter variations can accurately determine the offset from the rotation axis to the center of the wafer. Additionally, the process can identify the orientation of the wafer because most semiconductor wafers have an orientation indicator such as a notch or a flat on its perimeter. An edge detector detects when the flat or notch in the wafer's perimeter rotates past. Examples of such position detector systems, which are often referred to as prealigners, are described in U.S. Pat. No. 4,457,664 of Judell et al., U.S. Pat. No. 5,308,222 of Bacchi et al., U.S. Pat. No. 5,511,934 of Bacchi et al., and U.S. Pat. No. 5,513,948 of Bacchi et al. Prealignment for an X,Y stage requires addition of structure such as a separate prealignment station, from which the wafer is transferred to the X,Y stage after prealignment, or a rotatable sub-stage on the X,Y stage for rotating the wafer.

LAW OFFICES OF
SKJERVEN MORRILL
MACPHERSON LLP

25 METRO DRIVE
SUITE 700
SAN JOSE, CA 95110
(408) 453-9200
FAX (408) 453-7979

Please replace the paragraph starting on page 2, line 29 with the following replacement paragraph.

A3

Fig. 2 illustrates a system 200 using a polar coordinate stage 220 to position sample

A3 concl.

110. Polar coordinate stage 220 has a rotatable platform mounted on a linear drive mechanism. The linear drive mechanism moves the platform and a sample along a coordinate axis R, and the platform rotates the sample about the rotation axis of the platform. Polar coordinate stage 220 requires significantly less area when positioning sample 110 for edge-to-edge inspection. In particular, a travel distance r (the radius of the sample) along axis R out to a position 212 is sufficient to center in field of view 130 any radial coordinate ρ in the range from 0 to r. Rotation of sample 110 then selects an angular coordinate θ so that any point on sample 110 can be positioned in field of view 130. Since polar coordinate stage 220 only requires one-dimensional linear motion and half the travel distance of an X,Y stage, the polar coordinate stage takes much less area than an X,Y stage requires. In particular, a polar coordinate stage needs an area of about $6*r^2$, which is less than 40% of the area that an X,Y stage requires.

Please replace the paragraph starting on page 4, line 11 with the following replacement paragraph.

A4

In one embodiment of the invention, the imaging system includes active opto-mechanical image correction. For example, when the imaging system includes an optical microscope, an optical element such as a dove prism rotates an image by an amount that depends on the variable property of the optical element. When the imaging system includes a scanning beam microscope, such as a scanning electron beam microscope, the active image rotation unit rotates the scan direction to rotate the image. The control system calculates and applies the required signals to adjust the active image correction device and achieve the necessary image correction. For example, the control system can rotate a dove prism or a beam deflector at the appropriate rate and direction to maintain the image orientation while the stage moves. Alternatively, the imaging system provides a first image signal representing an image that rotates as the stage rotates the sample, and the control system electronically processes the first image signal to generate a second image signal that maintains the desired orientation while the stage rotates.

LAW OFFICES OF
SKJERVEN MORRILL
MACPHERSON LLP

25 METRO DRIVE
SUITE 700
SAN JOSE, CA 95110
(408) 453-9200
FAX (408) 453-7979

Please replace the paragraph starting on page 6, line 13 with the following replacement paragraph.

A5

FIG. 3 illustrates a measurement system 300 in accordance with an embodiment of the invention. System 300 includes a polar coordinate stage 320, an imaging system 330, an operator interface 340, a control system 350, and an edge detector 360. Polar coordinate stage 320 is a standard polar coordinate stage such as commercially available from a variety of sources and includes a linear drive that moves a rotatable platform on which sample 310 is mounted. Polar coordinate stage 320 can rotate sample 310 by 360° about a rotation axis of the platform. A rotary encoder monitors the angular orientation θ of the platform relative to a linear drive direction, which is the direction along which the linear drive moves the platform as the linear drive setting ρ changes. The linear drive direction is also referred to herein as the R coordinate axis. A linear encoder monitors the linear position of the platform along the R coordinate axis. The maximum linear travel of the platform along the R coordinate axis determines the radius of the largest sample which imaging system 330 can view completely, assuming that imaging system 330 is stationary.

Please replace the paragraph starting on page 6, line 28 with the following replacement paragraph.

A6

Imaging system 330 is for viewing or inspecting regions of sample 310. In system 300, imaging system 300 is an optical microscope that includes a lamp 332, a beam splitter 333, lenses 334 and 335, and a camera 338. In operation, beam splitter 333 reflects light from lamp 332 onto an object area on sample 310, and objective lens 334 produces a magnified reflected light image of the object area. Lens 335 projects the image into camera 338, and camera 338 generates a signal representing the image that a monitor 348 displays. Lenses 334 and 335 are merely illustrative of optical elements. Additional optical elements are typically required to achieve the desired field of view and magnification of a suitable imaging system 330. In one embodiment, imaging system 330 includes a confocal microscope.

Please replace the paragraph starting on page 7, line 27 with the following replacement paragraph.

LAW OFFICES OF
SKJERVEN MORRILL
MACPHERSON LLP

25 METRO DRIVE
SUITE 700
SAN JOSE, CA 95110
(408) 453-9200
FAX (408) 453-7979

A7

In an alternative embodiment, imaging system 330 includes a scanning beam microscope such as an electron beam microscope or an ion beam microscope that scans a region of sample 310 and forms a video image. The video image conventionally has horizontal raster lines which correspond to the scanning direction of the scanned beam. In such an embodiment, image rotation unit 336 includes a beam deflection system that can rotate the direction of scanning. Rotating the direction of scanning direction results in a rotation of the image on monitor 348.

Please replace the paragraph starting on page 8, line 5 with the following replacement paragraph.

A8

Operator interface 340 is for observing the image of an object area of sample 310 and controlling movement of the field of view of imaging system 330 across sample 310. Operator interface 340 includes monitor 348 and operator control 342. Monitor 348 is a conventional video monitor capable of displaying an image represented by a signal from video camera 338. In particular, monitor 348 displays the image of the object area of sample 310, and an operator uses operator control 342 to change the object area in the field of view of imaging system 330. Operator control 342 is for inputting movement commands and directing the motion of the field of view across sample 310. In an exemplary embodiment of the invention, operator control 342 is a joystick but many alternative operator controls are suitable. For example, a region of monitor 348 can display control buttons that are software operated through the actions of a touch sensitive screen, a mouse, a track ball, a touch pad, or another pointing device. In the exemplary embodiment, an operator, observing the image from camera 338 on monitor 348, moves the joystick in a direction which corresponds to the direction in which the field of view should move relative to the displayed image. The degree of joystick movement determines the speed of image motion.

Please replace the paragraph starting on page 9, line 10 with the following replacement paragraph.

LAW OFFICES OF
SKJERVEN MORRILL
MACPHERSON LLP

25 METRO DRIVE
SUITE 700
SAN JOSE, CA 95110
(408) 453-9200
FAX (408) 453-7979

A9

Control system 350 also determines and applies signals to an angle control unit 356 and a radius control unit 358 so that stage 320 moves sample 310 at the desired speed in the

A9 concl.

desired direction relative to the displayed image. In the exemplary embodiment, control units 356 and 358 combined include a hardware interface conveying information to and from stage 320. Known computer controlled polar stages and their interfaces are suitable for system 300. Control system 350 further receives signals from edge detector 360 for a prealignment process described below. The prealignment process provides a precise indication of the orientation and position of sample 310.

Please replace the paragraph starting on page 10, line 6 with the following replacement paragraph.

A10

In one exemplary embodiment of system 400, stage 320 is a polar stage available from Kensington Laboratories and is used to mount semiconductor wafers up to 200 mm in diameter. Additionally, a z coordinate stage can be added to or integrated into stage 320 for focusing for imaging system 430 and/or measurement system 337. For example, imaging system 330 can attach to the z coordinate stage for focusing on a wafer on the polar coordinate stage. Imaging system 430 includes an optical microscope that provides a field of view at sample 310 which is about 1.3 mm x 1 mm. Imaging system 430 also directs light from a small spot (about 15 microns in diameter) at the center of the field of view to a spectrometer which collects data on the reflectance. This data can be used for determining the film thickness. A co-filed provisional U.S. patent App. entitled "Compact Optical Reflectometer System", of R. Yarussi and Blaine R. Spady, Ser. No. 60/092,384, describes some suitable measuring and imaging systems and is hereby incorporated by reference in its entirety.

Please replace the paragraph starting on page 10, line 21 with the following replacement paragraph.

A11

LAW OFFICES OF
SKJERVEN MORRILL
MACPHERSON LLP
25 METRO DRIVE
SUITE 700
SAN JOSE, CA 95110
(408) 453-9200
FAX (408) 453-7979

Control system 450 is a computer such as a 400 MHz Pentium II-based personal computer having a video capture board for connection to video camera 338 and an interface for connection to stage 320. Video capture boards capable of performing real time image rotation are commercially available from a variety of sources including, for example,

A11 concl.

Visicom, Inc. The interface board required for connecting control system 450 to stage 320 depends on the stage manufacturer. In this embodiment, operator control 342 is implemented in software as controls appearing on monitor 348.

Please replace the paragraph starting on page 10, line 29 with the following replacement paragraph.

A12

Before an operator uses system 300 or 400 to measure or inspect sample 310, prealignment and alignment processes accurately determine the position and orientation of sample 310. Typically when a sample such as a wafer is placed onto stage 320, the position of the center of sample 310 is known only to within one or two millimeters, and the angular orientation of the sample 310 may be completely unknown. In accordance with an aspect of the invention, a prealignment procedure uses edge detector 360 and stage 320 to determine the position and orientation of sample 310. For the prealignment procedure, a light source (not shown) below sample 310 illuminates sample 310, and sample 310 casts a shadow onto edge detector 360. Edge detector 360 includes a linear detector array located above sample 310 and precisely identifies the edge location of the shadow of sample 310 while stage 320 rotates sample 310 through 360°. If sample 310 is nearly circular but not perfectly centered on the stage, the position of the shadow on detector 360 moves slightly as stage 320 rotates sample 310.

Please replace the paragraph starting on page 12, line 10 with the following replacement paragraph.

A13

Fig. 6 shows a flow diagram illustrating a process 600 for control of the polar coordinate stage 320 and image rotation unit 454 and determination of the position of sample 310 on stage 320 of Fig. 4, during measurement or inspection of sample 310. An initial block 610 initiates the system control program in control system 450. An initial inquiry 620 of process 600 determines whether sample 310 is present on stage 320. An object-present sensor or the operator responds to inquiry 620. If no sample is present, process 600 ends in step 625 by reporting an error (no sample present). If sample 310 is present, block 630 implements the

LAW OFFICES OF
SKJERVEN MORRILL
MACPHERSON LLP

25 METRO DRIVE
SUITE 700
SAN JOSE, CA 95110
(408) 453-9200
FAX (408) 453-7979

A13 concl.

prealignment/alignment process described above. In particular, stage 320 rotates sample 310, edge detector 360 measures edge positions, and control system 450 analyzes the edge position measurements to identify an offset between the rotation axis of stage 320 and the center of sample 310. If necessary, sample 310 is then more precisely aligned or located using a deskewing procedure. Prealignment/alignment step 630 can be omitted when precise alignment of sample 310 is not required, for example, when sample 310 is simply inspected visually.

Please replace the paragraph starting on page 12, line 25 with the following replacement paragraph.

A14

Once sample 310 is present and properly aligned, process 600 moves sample 310 according to the commands from an operator. In step 640, control system 400 receives Cartesian input commands from the operator. The input commands indicate a desired movement direction and speed relative to the image on monitor 348. Step 650 converts the Cartesian input commands to polar coordinate output commands for stage 320, and block 660 applies the appropriate signals to stage 320 to move sample 310. Step 670 is simultaneous with step 660 and rotates the image to cancel the rotation of sample 310 in step 660.

Please replace the paragraph starting on page 13, line 3 with the following replacement paragraph.

A15

To illustrate conversion and image rotation steps 660 and 670, Fig. 7 shows the relationship between the X and Y coordinate axes and the R coordinate axis of stage 320. The X and Y axes are fixed on sample 310 and centered on the rotation axis 710 of the platform on which sample 310 is mounted. As noted above, rotation axis 710 is typically offset from the center of sample 310 by an amount determined during prealignment and/or alignment. Rotation axis 710 of stage 320 passes through the R coordinate axis. The R coordinate axis corresponds to the direction of linear motion of stage 320 and has an origin that remains in the center of a field of view 740 of the imaging system. A view point 720 on sample 310, which is currently at the center of field of view 740, has polar coordinates ρ and θ relative to rotation axis 710. Coordinate ρ is the distance that stage 320 moved sample 310. Coordinate θ is the

LAW OFFICES OF
SKJERVEN MORRILL
MACPHERSON LLP

25 METRO DRIVE
SUITE 700
SAN JOSE, CA 95110
(408) 453-9200
FAX (408) 453-7979

A14 concl

angle through which stage 320 rotated sample 310.

Please replace the paragraph starting on page 13, line 15 with the following replacement paragraph.

A16

Image rotation 670 preserves the orientation of the X and Y axes as viewed on monitor 348. For example, the X axis if initially horizontal remains horizontal on monitor 348 regardless of how stage 320 rotates sample 310. Accordingly, if the X axis is initially along the R axis, step 670 rotates the image by -θ, where θ is the polar coordinate of view point 720.

Please replace the paragraph starting on page 14, line 4 with the following replacement paragraph.

A17

Alternatively, when stage 320 uses coordinate settings rather than velocity settings, the input commands are sampled at a fixed frequency so that the components Vx and Vy indicate small displacements ΔX and ΔY which are the product of the velocity components and the time between samples. Displacements ΔX and ΔY shift a point 730 to the center of the field of view 740. In this case, step 650 converts the displacements ΔX and ΔY to polar displacements Δθ and Δρ. The polar displacements Δθ and Δρ have magnitudes that depend on displacements ΔX and ΔY and the coordinates (X,Y) or (θ ,ρ) of current view point 720. Such conversions involve well known geometric techniques. It is desirable that stage 320 move sample 310 uniformly so that the displacements ΔX and ΔY require the full time between consecutive samplings of the input commands. Accordingly, to achieve this, the stage velocities need to vary according to the magnitude |V|, and the angular velocity needs to vary with radius. However, discontinuous shifts of sample 310 are imperceptible by the operator if the sampling period is sufficiently short, for example, if the sampling and shifting rate is higher than the frame rate of monitor 348.

LAW OFFICES OF
SKJERVEN MORRILL
MACPHERSON LLP

25 METRO DRIVE
SUITE 700
SAN JOSE, CA 95110
(408) 453-9200
FAX (408) 453-7979

Please add the following paragraph starting on page 14 between lines 19 and 20.

A18

A step 680 gets and converts the stage position, and a step 685 can then store or display the position and the rotated image for inspection process 600. After display of the